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**TITLE                      Voting Technology, Vote-by-Mail, and Residual  
Votes in California, 1990-2010**

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# Voting Technology, Vote-by-Mail, and Residual Votes in California, 1990–2010\*

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## Abstract

This paper examines how the growth in vote-by-mail and changes in voting technologies led to changes in the residual vote rate in California from 1990 to 2010. We find that in California's presidential elections, counties that abandoned punch cards in favor of optical scanning enjoyed a significant improvement in the residual vote rate. However, these findings do not always translate to other races. For instance, find that the InkaVote system in Los Angeles has been a mixed success, performing very well in presidential and gubernatorial races, fairly well for ballot propositions, and poorly in Senate races. We also conduct the first analysis of the effects of the rise of vote-by-mail on residual votes. Regardless of the race, increased use of the mails to cast ballots is robustly associated with a rise in the residual vote rate. The effect is so strong that the rise of voting by mail in California has mostly wiped out all the reductions in residual votes that were due to improved voting technologies since the early 1990s.

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# Voting Technology, Vote-by-Mail, and Residual Votes in California, 1990–2010

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A decade ago, the nation became aware that voting machines are not simple ciphers through which voters cast their ballots. Palm Beach County, Florida provided the best illustration of how machine malfunction — exemplified by “hanging” and “pregnant” chad — and poor ballot design — exemplified by the “butterfly ballot” — could result in a vote being miscounted, if counted at all (e.g., Sinclair et al. 2000; Smith 2002; Wand et al. 2001).

The Florida fiasco resulted in a strong public demand for improved voting technology, and led to a flurry of new research into the causes of “lost votes” due to voting technologies.<sup>1</sup> Within political science, this research has focused on explaining the residual vote rate in presidential elections as a function of the type of voting technology used by voters. (The residual vote rate is the percentage of ballots cast that either contain an over- or undervote for a particular race.) Making this research particularly important was the simultaneous emergence of public demand for improved voting technology to reduce the residual vote rate. This was made explicit by the Help America Vote Act which mandated retirement of older technologies and resulted in billions of state and federal dollars being spent to retire old voting machines.

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<sup>1</sup> For example, Alvarez et al. 2005; Ansolabehere 2002; Ansolabehere and Stewart 2005; Stewart 2006; Kimball and Kropf 2008; Sinclair and Alvarez 2004; Tomz and Van Houweling 2003. See Stewart (2011) for a review of research on voting technology in general.

Despite the importance of this line of research, at least two significant questions have not been addressed in the scope of residual votes. First, despite the fact that American elections are noted for their long ballots, the new research has largely ignored residual votes for races further down the ballot, such as for state and local offices or ballot measures. Second, at the same time that states and local jurisdictions across the country have retired their antiquated voting technologies in a drive to push down the number of lost votes, many of the same states and localities have seen a surge in voting by mail, either by liberalizing absentee ballot laws or mandating vote-by-mail altogether. How this has affected residual vote rates remains unknown.

The purpose of this paper is to use recent elections in California as a laboratory to help address these two questions, (1) whether changes in voting technologies have the same effects in reducing lost votes in races other than the president and (2) whether the rise of voting by mail has reinforced federal voting technology policy. The answer to the first question is a qualified “yes.” The answer to the second question is a qualified “no.”

California provides an apt laboratory for answering these questions because of its size, length of ballot, use of various voting technologies, and because of the importance of its ballot measures. Studying how voting technologies affect lost votes down the ballot is difficult in nationwide research because states are highly variable both in the number of offices that are up for election, including those on the statewide ballot, and in specifying the order in which offices appear on the ballot. The number of statewide offices in California is exceptional, which allows us to study the down-ballot effects with some precision. Finally, the general structure of the ballot is fixed across the state, allowing for local offices to be sandwiched between the statewide races at the top and ballot measures toward the bottom of the ballot.<sup>2</sup> Moreover, because of the

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<sup>2</sup> Section 13109, subsection n of California’s Election Code states that ballots measures should appear on the ballot after all candidate races, and that state measures should appear before local measures.

significant independent authority of the constitutional officers who are on the statewide California ballot, most of these positions are hotly contested. This minimizes (though does not eliminate) the problems that arise when studying low turnout elections.

In addition, California is notable for the number, intensity, and policy significance of its ballots measures.<sup>3</sup> Although California has not been alone in facing fiscal difficulties during the current recession, Cain and Noll (2010) argue that the initiative process has made fiscal affairs in California especially difficult to manage, by centralizing revenue-collection in Sacramento while fostering soft budget constraints for local government spending. Therefore, it is important to understand whether voting technologies influence the quality of direct democracy in the state.

Using a pooled cross-sectional time series data set of California elections from 1990 to 2010, this paper finds the following:

1. The shift from Votomatic punch cards to optical scanning technologies has generally improved the residual vote rate in all types of elections in California. The transition from Votomatic punch cards to DREs in a few counties, which was reversed by a mid-decade decision of the Secretary of State, was also generally effective in reducing the residual vote rate, though less consistently than was the case with optical scanning.
2. Los Angeles County, which adopted a unique voting system, the InkaVote, to replace the Votomatic system, has recovered votes in presidential and gubernatorial elections to a degree similar to counties that adopted optical scanning technologies. However, these gains have not carried over to senatorial

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<sup>3</sup> For example, see Boehmke 2005; Gerber 1999; Gerber, McCubbins and Kiewiet 2001; Hajna, Gerber, and Louch (2002); Kahn and Matsusaka (1997); Lupia (1994); and Matsusaka 2004.

elections, or to ballot propositions, where InkaVote has performed only slightly better than Votomatic, and clearly worse than either optical scanning or DREs.

3. The residual vote rate among California's propositions has been reduced significantly because of the various rounds of voting machine replacement over the past decade. In 2008, for instance, we estimate that almost 107,000 more votes were counted in each of the ballot measure contests than would have been the case without the retirement of the Votomatic punch cards.
4. The rise of vote-by-mail in California has led to a steady rise in the residual vote rate up and down the ballot, undoing almost the entire benefit associated with improvements in voting technologies.

The remainder of the paper is organized as follows. Section I reviews previous research on the relationship between voting technology and residual votes. Section II reviews the data that are analyzed in this report. Section III discusses issues of model specification and estimation. Section IV reviews the results. Section V concludes.

## I. Previous research

Research into the cause of lost votes since the 2000 Florida recount has focused on understanding how voting technologies influence whether the votes cast by voters — or that voters *think* they have cast — are in fact counted. A related question is whether there is something about particular technologies, especially the ballot layouts employed, which induces voters to abstain from or participate in particular races on the ballot. The two questions are related empirically, but have different intellectual roots.

The second question, whether different technologies encourage abstention, was the focus of the voting technology literature before 2000, to the degree it existed. The dependent variable

was “roll-off,” defined as the difference in the number of ballots cast for the race at the top of the ticket, usually president, and some race further down the ballot, including initiatives. The cause of roll-off was taken to be the evocatively-termed “voter fatigue,” induced by the strain put on low-information voters, as they tried to navigate through a ballot that contained increasingly obscure offices, moving from top to bottom. This literature initially began with an interest in the effect of ballot design on roll-off, with the preeminent study being Walker (1966), which focused on ballot form (party list vs. office bloc). Eventually, research turned to the issue of voting technology itself.

Table 1 summarizes these pre-2000 studies of roll-off that focused on voting technology, noting the down-ballot races studied and the general findings that relate to voting technology. Two consistent findings emerged from this research. First, mechanical voting machines regularly produced more roll-off than paper methods in voting on referenda. Second, electronic voting machines generally produced less roll-off in down-ballot races.

[Table 1 about here]

As Table 1 also indicates, some of the earliest studies about voting technology and roll-off focused on ballot questions. These studies were in reaction to astonishingly high roll-off rates in referenda, comparing counties that used mechanical lever machines to counties that still used hand-counted paper ballots. For instance, Thomas (1968, Table 4) showed that the roll-off rates for constitutional revision referenda in Michigan held in 1958, 1960, 1961, and 1963 that

were cast on paper ballots were 13%, 13%, 1%, and -5%,<sup>4</sup> respectively, compared to rates of 39%, 35%, 17%, and 5% in counties that used lever machines.<sup>5</sup>

As column 5 of Table 1 indicates, with only a couple of exceptions, the dependent variable in these studies was roll-off, calculated as the difference between the total votes cast in the down-ballot race (or ballot question) and the race at the top of the ticket, even in those cases in which total turnout was reported by the state. Thus, the underlying behavioral model of this research — though never articulated directly — was that any over- or under-votes in the top race reflected a conscious abstention in that race. A notable exception was Asher, Schussler, and Rosenfield (1982), whose research was prompted by an inexplicable number of missing votes at the top of the ticket — roll-*on*, as it were — in an Ohio gubernatorial election. Their paper aside, the implied behavioral model of the roll-off literature was a bit convoluted. Therefore, it was not of much help in understanding the 2000 Florida controversy, since the office of concern there was president.

Research into how voting technology can influence the act of voting shifted in response to Florida in two related ways. First, the office of concern moved to the top of the ballot, particularly in presidential years. Second, the dependent variable was recast as the “residual vote rate,” which was defined as total turnout minus the number of total ballots cast in a particular race, all divided by total turnout. Stewart (2011) recently reviewed this literature, finding numerous articles, books, and reports that have used the residual vote rate as a dependent variable. Almost all of these focus on the presidential election, with the only notable exceptions

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<sup>4</sup> Presumably, in 1963, more people voted in the referendum on the constitutional revisions in counties using paper ballots than voted on the top partisan race on the ballot.

<sup>5</sup> Thomas expressed the dependent variable as the “participation rate,” which we have subtracted from 100%, to make comparable to most other roll-off literature and the residual vote literature that is discussed next.



being Caltech/MIT Voting Technology Project (2001), Ansolabehere and Stewart (2005), Kimball and Kropf (2008), and Lott (2009). Because its design and findings have the most bearing on the current paper, we discuss Kimball and Kropf's research in more detail below.

The empirical coverage of this new line of research is limited to states that require their local jurisdictions to report total turnout. Not all states require this, and therefore it is not possible to conduct residual vote research in every jurisdiction (Alvarez, Ansolabehere and Stewart 2005). Luckily, the number of states (and the District of Columbia) reporting turnout has risen since 2000, from 39 then to 46 in 2008, and so it has become easier to conduct residual vote research in large nationwide studies.

In the mainstream post-2000 residual vote research, punch card systems consistently emerged as the biggest culprits in producing residual votes. The Help America Vote Act (HAVA) required that states retire this technology, in favor of DREs and optical scanners. One consequence of HAVA's implementation is that, roughly one million more votes for president were accounted for in the 2004 presidential election. The 2008 election showed comparable gains (Stewart 2006).

Despite all the research that has documented the effects of voting technologies on residual votes, a number of important questions remain unstudied. One of those is how voting technologies affect residual votes "down-ballot," that is, for races other than president or governor, especially ballot measures. Consequently, the pre-2000 interest in the effects of voting technology on the set of elections that are more consequential for state and local politics, and where technology appeared to have the biggest impact on outcomes, has been lost.

In a recent effort to initiate study of this question, Kimball and Kropf (2008) examined residual votes in 1,999 counties drawn from 34 states in the 2004 presidential election. Their

analysis demonstrated that like previous studies of residual votes, the type of voting technology employed had an important association with the residual vote rate. They also showed that the exact relationship between voting technology and residual vote rates was not the same at the presidential level compared to ballot measures. For example, they found that although punch cards were the worst performing technology in terms of residual votes in presidential elections, punch cards were much better than lever machines or full-faced DREs in preserving votes on ballot measures.

However, their analysis was based on only one election year (2004), choosing to study elections across 34 states. Therefore, their analysis might not have fully controlled for the potential array of administrative, procedural, legal, and political differences that existed in that election over the set of states they study. In contrast, our panel study's focus on California should shed better light on the causal connection between voting technologies and residual vote rates, while also keeping many administrative, procedural, and contextual factors constant (as our analysis is restricted to a single state).

Another important question that has been under-studied is how residual vote rates differ by voting mode. Typically, residual vote studies assume that all of the ballots included in the analysis have been cast in identical ways in a county — with the same technology and using the same administrative procedures. While that assumption might not have been problematic in 2000, when the residual vote rate measure was invented and there were few ballots cast outside of polling places on Election Day, administrative practices have changed considerably since then. In some states like Oregon and Washington, all or nearly all ballots are now marked by voters before Election Day, outside of the administrative control of election officials, and sent by mail. In many other states (California being a prominent example), the number of ballots marked

before Election Day and cast by mail has increased dramatically. In some places, voters can even vote before the election in a satellite voting location (“early voting”).

Voters who mark their ballots outside a polling place or satellite-voting center cannot take advantage of technological means to check their marked ballots for common errors, like overvotes or undervotes. Thus, residual vote rates may differ significantly between in-person and by-mail ballots. Jurisdictions with more by-mail voting may have higher residual vote rates, all things being equal.

## II. Data

The data from this paper were taken from the publication *Statement of Vote*, which is compiled after each statewide primary and general election by the California Secretary of State.<sup>6</sup> These data include turnout (termed “total voters” in the report), number of residual votes (usually labeled “votes not cast in race”), and voting technology. When the number of residual votes was not reported explicitly, they were calculated by subtracting the number of votes for candidates or ballot measures from turnout.

The unit of analysis is the county-year. Counties are the appropriate geographic unit of analysis, because counties administer statewide elections. By obtaining data from multiple years, we create a panel dataset, which allows us to account for confounding county-specific effects in a simple, straightforward way that is described below, and which has been used in similar research in the past (Caltech/MIT 2001; Ansolabehere and Stewart 2005; Stewart 2006).

We gathered the relevant data for ballot measures, president, U.S. senator, and governor for the 1990–2010 period. We excluded the 1992 special election for U.S. senator, in which Diane Feinstein was elected to serve out Pete Wilson’s incomplete term. We also excluded

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<sup>6</sup> The URL for these reports is [http://www.sos.ca.gov/elections/elections\\_elections.htm](http://www.sos.ca.gov/elections/elections_elections.htm).

ballot measures that appeared on primary ballots, because the electorates in those elections are significantly different from general elections, even taking into account that the electorates for on- and off-year general elections are likely to differ, as well.

Table 2 reports the statewide residual vote rates for presidential, gubernatorial, U.S. Senate, and proposition elections during this period. Figure 1 illustrates this data graphically.

Table 2 about here

Figure 1 about here

Overall, the residual vote rates have averaged, 1.7%, 2.8%, and 4.3% for president, governor, and senator, respectively. The presidential and gubernatorial races are at the very top of the ballot in on- and off-years, respectively, so there is no surprise that these rates should be low. The U.S. Senate race is never at the top of the ballot and, in mid-terms, can be far down the ballot because all statewide positions appear above it.<sup>7</sup> Therefore, it is unsurprising that the residual vote rate for U.S. Senate is always higher than the top-of-the-ballot races, both overall, and in the year-by-year comparison.

Table 2 also reports summary statistics for residual votes among the ballot measures, with Figure 1 illustrating this information graphically. The hollow squares in the figure report the average rates across all ballot measures, while the “whiskers” report the minimum and maximum rates.

The overall residual vote rate for ballot propositions, 9.3%, is much higher than for the three statewide positions studied here, but there is considerable variability around this mean.

While no proposition has ever had a lower statewide residual vote rate than the concurrent

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<sup>7</sup> This is established by Section 13109 of California’s Election Code. This section specifies that presidential and state constitutional officers (Governor, Lieutenant Governor, Secretary of State, Controller, Treasurer, Attorney General, Insurance Commissioner, and Member of State Board of Equalization) will always precede U.S. Senate candidates when presidential or state constitutional officers are on the general election ballot.

presidential or gubernatorial election, two propositions had lower statewide residual vote rates than the concurrent senatorial election.<sup>8</sup>

### III. Method and Estimation

The focus in this paper is on the role that voting technologies play in determining the residual vote rate in California elections. The statistical technique used to quantify that role is fixed-effects regression, which is the technique used by Ansolabehere and Stewart (2005) and Stewart (2006) in studies of the residual vote rate nationwide. The idea behind fixed effects regression is that much of the heterogeneity we observe in residual vote rates, both cross sectional and longitudinal, can be explained by unobserved factors that are (assumed to be) constant for the period of the study.

In this study, we treat three factors as fixed, and account for them with a series of dummy variables: county, year, and ballot measure. This is in lieu of searching for measures of covariates specifically, which would leave some important confounding variables unmeasured, resulting in statistical bias we are trying to avoid. This strategy also helps with efficiency, which is important, because residual vote rates are highly variable, and the technology-related influences on them are generally small.

The county fixed effects take into account demographic and administrative practices that are associated with each county — factors which might lead to variations in residual vote rates across counties, even in the absence of technology variations. Counties that have a large number

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<sup>8</sup> The first was Proposition 187 in 1994, which restricted public services provided to illegal immigrants, with a 3.5% residual vote rate, compared to 4.3% for the concurrent senatorial election that pitted Diane Feinstein (D) against Michael Huffington (R). The second was Proposition 86 in 2006, which would have amended the state constitution to impose a \$2.60 excise tax on cigarettes, which had a 3.8% residual vote rate, compared to 4.0% for the concurrent senatorial election that pitted Feinstein against Dick Mountjoy (R). The residual vote rate for Proposition 8 in 2008, which prohibited single-sex marriage in the state, was only 2.5%, but it was still greater than the residual vote rate for the presidential election, which was 1.3% in the Obama-McCain contest.

of residents who are poorly educated, are less politically engaged, or have poor eyesight are likely to have elevated residual vote levels. In addition, counties that regularly produce ballots that are confusing or that poorly inform their voters how to avoid making mistakes may also have elevated residual vote levels. Some of these factors, such as education, may be measurable, albeit imprecisely. Most of these factors will be outside our practical ability to measure. If we do not control for them, we risk both bias and inefficiency. To minimize these risks, we include dummy variables for each county.

The year fixed effects take into account the fact that numerous factors specific to each election year influence the residual vote rate, quite independently of the voting technologies used. For instance, popular incumbents often run for reelection against low-quality challengers; the “disadvantaged” party in a year that is considered *ex ante* to be “bad” for that party (as 1974 was for Republicans and 2010 for Democrats) may be unable to attract high-quality challengers in those years. In these cases, the asymmetry in candidate quality may lead to partisans from the party of the low-quality candidate simply to abstain, rather than support either a candidate whose views they do not endorse (the incumbent) or a candidate they do not believe can do the job (the challenger). In other cases, the presence of a strong third party candidate may induce a few voters who would otherwise have abstained to make the unconventional choice. In each of these cases, the residual vote rate will expand and contract because of variations in deliberate abstentions. The inclusion of year-specific dummy variables will account for fluctuations in the residual vote rate that are due primarily to the candidates standing for election, making our estimates of the technology effects more precise.

The proposition effects similarly take into account factors specific to each ballot measure that influence the tendency to abstain. Previous research suggests that particular types of ballot

measures tend to have higher residual vote rates than others. In particular, referenda placed on the ballot by state legislatures tend to have higher residual vote rates than citizen initiatives (Mueller 1969; Magleby 1984; Bowler et al. 1992; Kimball and Kropf 2008). In addition, initiatives and referenda vary considerably in how easily they are understood by the average voter, and therefore in how often voters abstain due to uncertainty or confusion. To take into account the tendency of some ballot measures to prompt more abstentions than others, we include a separate dummy variable for each measure. Because the ballot measure dummies are collinear with the year dummies, we omit the year dummies in the analysis of the ballot measures.

With the fixed effects providing estimates of the baseline residual vote rates, we focus on three other factors, which vary across counties and across time — voting technology, turnout, and the prevalence of vote-by-mail. We describe each in turn.

### *Voting technology*

We measure voting technology two ways. First, we use a series of dummy variables to indicate whether county  $c$  used one of six different types of voting technology in year  $t$ . These technology types are central-scan optical scanning, precinct-scan optical scanning, direct recording electronic (DRE), Votomatic punch card, DataVote punch card, and InkaVote.<sup>9</sup>

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<sup>9</sup> The *Statement of Vote* document does a thorough job in describing which voting technology each county used for the entire period covered by this paper. It does not indicate whether votes were tallied in the precincts or centrally, for those counties that used optical scanners. Unfortunately, many of the optical scanners used in California may be used both in precincts and centrally, so we could not code the type of optical scanner directly from the Secretary of State's document. Instead, we relied on two documents to piece together whether optical scanning equipment was used in-precinct or centrally: Arnold (1999) and the 2008 Election Assistance Commission *Election Administration and Voting Survey* dataset.

Votomatic punch cards — the technology used by the most voters during this period — are the omitted category. Table 3 reports the usage of the equipment, by year.

[Table 3 about here]

One technology type, the InkaVote, deserves special comment.<sup>10</sup> InkaVote was adopted by Los Angeles County beginning in 2003. Although technically an optical scan system, its design was an adaptation of the Votomatic punch card technology that Los Angeles County previously used. We have chosen not to fold the InkaVote into the central-count optical scan category for two reasons. First, the InkaVote really is a hybrid. Unlike the other optical scanning technologies, the InkaVote ballot is first placed in a vote recorder, like the Votomatic. The ballot is then marked like the old Votomatic system was, with a felt-tipped pen replacing the stylus. Therefore, the InkaVote interface is fundamentally different from the other optical scan technologies. Second, because Los Angeles County has begun a process to assess whether the InkaVote system should be replaced, it is natural to ask how its unique system fares in comparison with the other standard voting technologies (LACRR 2010).

As noted, we distinguish between optical scanners that were used to tabulate votes in the precinct from those that were used centrally. Kimball and Kropf (2008) and others have shown that precinct-scanned machines tend to have lower residual vote rates than central-scanners in presidential balloting, though they did not find the same effect for down-ballot races. They also find that optical ballot styles that require voters to fill in ovals tend to have lower residual vote rates in presidential voting than ballots that require voters to complete the point and fletching of

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<sup>10</sup> Throughout this paper we use the term “InkaVote” to describe the voting system that Los Angeles County uses. The system is also called “InkaVote Plus”, a term used today to describe the enhanced version of “InkaVote” now used by Los Angeles County that includes the vote recorder, a precinct ballot reader that scans ballots for mistakes like overvotes and blank ballots, and an audio ballot booth that can be used for voters who desire to use audio equipment to assist them as they mark their ballot.



an arrow. Again, Kimball and Kropf find much weaker effects when it comes to initiatives. Because we were unable to collect sample ballots for all counties for the period covered in this paper, we were unable to code this attribute of voting systems. We assume that most of the “oval vs. arrow” effect will be captured in the county fixed effects.

Finally, Kimball and Kropf (2008) tested differences between full-face DREs and machines with smaller screens that require voters to scroll through the ballot. None of the DREs used in California during this period were full-face, therefore we are unable to test that distinction here.

We measure technology a second way, by entering a dummy variable equal to one in an election year in which a county *first* uses a particular voting machine, zero otherwise. Although intuition would suggest that the introduction of a new voting technology would tend to increase the residual vote rate, due to an increase in voter confusion, Ansolabehere and Stewart (2005) found that the effect was just the opposite — the introduction of new voting technologies tends to *decrease* the residual vote rate in top-of-the-ballot races. However, there has been no research into whether the extra effort at voter education that usually surrounds the introduction of new voting equipment similarly leads to reduced residual vote rates among ballot propositions. Therefore, we enter this second dummy variable to test these effects in this context.

### *Turnout*

One of the hypotheses to explain the longitudinal fluctuation in residual vote rates is that the surge of voters to the polls in particularly “hot” election years brings more inexperienced voters to the polls, thus producing more residual votes. Ansolabehere and Stewart (2005) found precisely this effect, when they controlled for the underlying size of the election administration

unit. To control for the turnout surge effect on the residual vote rate, we include the natural logarithm of turnout for county  $c$  in election year  $t$ .

### *Vote-by-mail*

One factor that has been virtually overlooked in previous studies of the effect of voting technology on residual votes is the effect of voting by mail. Almost every study of residual vote rates has implicitly assumed that all voters are using the in-precinct voting machines to cast ballots, despite the fact that an increasing number of voters are using the mails to vote, rather than going to a polling place on Election Day (Gronke, Stewart, and Hicks 2010).<sup>11</sup> California is one state where the trend toward vote-by-mail has been swiftest. During the period covered by this paper, the percentage of ballots cast by mail has risen from 18% in 1990 to 48% in 2010. California has adopted a “permanent absentee” provision and has ceased using the term “absentee voting” to label voting by mail. Alpine County has voted entirely by mail in general elections since 1994, as has Sierra County since 2004.

The assumption that all ballots in a county are cast in-precinct is problematic in estimating the effect of voting technology on the residual vote rate for several reasons. First, the voting technology used to cast and tabulate mail ballots can be different in the two modes. This is particularly true when a county uses a DRE for its polling place method, because it must use an optical scanning technology to handle the absentee ballots. Even when optical scanning is the in-precinct method, if a county uses in-precinct counting of polling place ballots, the ballot interface for mail-in ballots may be the same, but the counting technique will be different, because the mail-in ballots are counted centrally. Even when the same technology is used for in-

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<sup>11</sup> There are few studies of residual vote rates for any form of convenience voting method. For example, in a recent review essay regarding convenience voting, Gronke et al. (2008) noted “It therefore remains unknown whether ballots that are cast earlier are generally of higher quality (that is, have lower levels of residual votes)” (p. 448).

precinct and absentee voting, the election process in the two settings will be quite different in any event, and it would be a mistake to estimate the effect of machines on the residual vote rate without taking this into account.

It would be ideal to estimate the residual vote rate separately for voters using the two main voting modes in California, in-precinct and vote-by-mail. However, only a few counties report the residual vote rates for in-precinct *vs.* vote-by-mail modes separately; none report this for the whole period covered by this paper. As an alternative, we have entered in the percentage of ballots cast by mail for county  $c$  in election year  $t$  as a control variable.<sup>12</sup>

### III. Results

Table 4 reports the results of the estimation, comparing residual vote rates of presidential, gubernatorial, and senatorial elections with those of the ballot measures voted on in these same statewide elections.<sup>13</sup> To help focus on the coefficients associated with voting technologies, Figure 2 graphs the values of the voting technology coefficients, along with error bars that depict the 95% confidence intervals. The top half of the graph groups the coefficients first by voting technology, then by race; the bottom half groups first by race, then by voting technology. The Votomatic punch card, the baseline category, is indicated with the horizontal line at zero along the y-axis.

[Table 4 about here]

[Figure 2 about here]

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<sup>12</sup> Better still would be to interact the percentage of vote-by-mail voting with the dummy variables indicating the in-precinct voting technology, to see if the mail-in ballot effect varies across the different voting technologies. Unfortunately, the results we obtained were very imprecise, so we confine ourselves here to simply estimating the direct effect of vote-by-mail.

<sup>13</sup> Because only one county that comprise a tiny fraction of the state's voters used mechanical lever machines in the 1990 and 1992 elections, we omit a discussion of those results.

The results for the three races, president, governor, and senator, are similar to those found in other nationwide studies. A switch from Votomatic punch cards to central-count optical scanning resulted in a reduction in the residual vote rate of between 0.7 and 1.3 percentage points for presidential, gubernatorial, and senatorial races. The effect of going from Votomatic punch cards to *precinct*-count optical scanning is quantitatively similar. A switch to precinct-count optical scanning in this case reduced the residual vote rate by 0.9 percentage points for president, 1.5 percentage points for governor, and 1.0 percentage points for senator.

For counties that abandoned Votomatic punch cards in favor of DRE's, the results are similar, although the residual vote rate reductions are on the whole smaller and less precisely estimated. The effect of moving from Votomatic punch cards to DREs is not statistically different from zero (at traditional levels of significance) in the case of presidential elections. Moving to DREs resulted in a residual vote rate reduction of around 1.4 percentage points in gubernatorial elections. The sign on the coefficient is also negative for senatorial elections, but the standard error is larger than the coefficient.

The InkaVote system yielded improvements in the case of presidential and gubernatorial elections that were similar to precinct-count optical scan systems. The estimated reduction in residual vote rates for these two types of races in Los Angeles County were 0.9 percentage points in each case. However, the results also suggest that InkaVote may be associated with an *increase* in the residual vote rate in senatorial elections, although the standard error is large enough that we could only reject the null hypothesis at  $p < .07$ .

As an aside, the coefficients associated with the DataVote punch cards also indicate that these machines, which were also banned by HAVA, produced residual vote rate at roughly the same levels as the more modern technologies. Therefore, for the voters in the twenty-one

counties that were required to relinquish DataVote punch cards after 2000, there is evidence that HAVA was a mixed blessing, in terms of lost votes, because some counties were required to adopt voting machines that were no better on the residual vote measure. On the whole, the DataVote coefficients are very similar to coefficients associated with optical scanning and DREs.

Overall, all the optical scanning technologies, including InkaVote, showed a significant residual vote rate improvement in the presidential and gubernatorial elections, while counties that adopted DREs to replace Votomatics only clearly showed improvements in the gubernatorial elections. Only the optical scanning technologies showed clear improvement with the down-ballot U.S. Senate elections and, indeed, the InkaVote system performed less well than the old Votomatic punch cards.

Turning now to the results pertaining to ballot measures, we see substantial improvements in residual vote rates from both types of optical scanning and DRE systems, and only a small improvement from InkaVote. Los Angeles County reduced its proposition residual vote rates by 0.42 percentage points, an improvement only one-quarter to one-fifth the size of the improvement for counties that moved to the other new technologies.

Overall, the effects of the voting technology changes in California during the past decade have been consistent. Counties moving to optical scanning have seen a definite drop in the residual vote rate in top-of-the-ballot races, and an even more significant drop in the residual vote rate for propositions. The effect of technology change on the residual vote rate for senator — a race nearer the bottom of the ballot — is decidedly mixed. For the InkaVote, the results have also been mixed, showing substantial improvements in presidential and gubernatorial elections, possible deterioration in U.S. Senate elections, and only a small improvement for ballot measures.

Table 4 also reports estimates for the effects of adopting new voting technology (regardless of the technology employed), the rise of vote-by-mail, and fluctuations in turnout. The adoption of *new* technologies was not related to any change in the residual vote rate in the case of president, senator, or propositions, only having the hypothesize effect in the case of governor. The turnout fluctuation effects are also statistically insignificant among the three offices and ballot propositions.

An especially interesting result reported in Table 4 pertains to the vote-by-mail coefficient, which is positive and statistically significant in each estimation. The interpretation of the coefficient is straightforward — it represents the estimated change in the residual vote rate if a county moves from no voting by mail to complete vote-by-mail. The size of the vote-by-mail coefficient is larger than the size of the coefficient for any voting technology.

Because the vote-by-mail coefficient is always large and positive while the coefficients associated with most new voting technologies in most settings are negative, this suggests that the lost votes recovered by California through the modernization of voting technologies may be being undone by the trend toward more voting by mail.

To test this supposition, Table 5 attempts to quantify changes in the residual vote rate in each county from the presidential elections of 1992 to 2008 due to changes in voting technologies and due to the growth in voting by mail. The table starts by reporting turnout in the 1992 and 2008 presidential elections; the percentage of ballots cast by mail in 1992 and 2008, along with the change across the two years; the type of voting equipment used in 1992 and 2008; and the estimated change in the residual vote rate from 1992 and 2008 based on changes in voting technology, using the coefficients from Table 4. It then calculates the estimated number of votes represented by this coefficient by multiplying it by turnout for 2008. Negative values

indicate an estimated reduction in the residual vote in 2008 due to technology changes since 1992. For instance, for Alameda County, we estimate that the change from punch cards in 1992 to precinct-count optical scanning in 2008 resulted in a reduction in the number of residual votes in 2008 by 5,343 ( $\approx -0.85\% \times 628,545$ ).

[Table 5 about here]

We then estimate the number of residual votes due to changes in the vote-by-mail rate in presidential elections by multiplying the relevant coefficient in Table 4 by the change in the vote-by-mail rate *and* the turnout for 2008. For instance, for Alameda County, we estimate that the growth in the vote-by-mail rate from 12.7% in 1992 to 48.3% in 2008 resulted in an increase in the number of residual votes in 2008 by 4,925 ( $\approx .022 \times [48.3\% - 12.7\%] \times 628,545$ ).

On net, improvements in voting technology roughly counterbalance the rise of residual votes due to the growth in vote-by-mail in presidential elections. The estimated effect of the voting technology improvements since 1992 is a reduction in the number of residual votes in the 2008 presidential election of 88,173; the vote-by-mail trend, on the other hand, has produced an increase in the number of residual votes of 73,868. That nets out to a decrease in residual votes in presidential elections of 14,305, or an overall decrease in the residual vote rate of 0.10 percentage points due to these two changes in election administration in California.

## VI. Discussion and conclusions

This paper has built on prior research to estimate how voting technologies have affected the “lost vote problem” in California over the past two decades. Like the studies that began the analysis of residual votes post-2000, we employed a panel data set to estimate the impact of changing voting technologies on the residual vote rate. Unlike past studies, we added two wrinkles. First, we added analysis of the rise of vote-by-mail, which has been the other major change in how the

electorate votes, especially in the west, since 2000. Second, we added analysis of elections beyond the presidential election, comparing across three major statewide races (president, governor, and U.S. senate) and the very significant set of ballot propositions that also dominate the politics of the Golden State.

The part of this paper that is parallel with past research produced similar findings to that earlier research, particularly in answering the core question of whether changing voting technologies can help address the problem of lost votes due to voting technologies. In California's presidential elections over the past two decades, counties that have abandoned punch cards in favor of optical scanning have enjoyed a significant improvement in the residual vote rate, which was the primary goal of the Help America Vote Act's mandated retirement of these older technologies. Among these counties, the effect was the addition of almost 32,000 additional votes to the tally in 2008. The effect of Los Angeles County's adoption of the InkaVote system can be credited with the addition of another 30,000 additional votes in the statewide tally. That increase is the equivalent of adding a county the size of Nevada County to California.<sup>14</sup>

The added features of this paper bring greater nuance to past findings. First, we show that findings that pertain to the presidential election do not necessarily translate to other races, either prominent ones near the top of the ballot, or potentially arcane ones among the ballot propositions. As far as voting technologies are concerned, there is a consistent finding that abandoning Votomatic punch cards in favor of optical scanning has produced an unambiguous increase in counted votes. The InkaVote system for Los Angeles has been a mixed success, performing very well in presidential and gubernatorial races, fairly well for ballot propositions,

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<sup>14</sup> Nevada County is approximately the median county in California, by voter turnout.



and poorly in Senate races. Statistically speaking, DREs prove no better than punch cards in presidential and senatorial elections, but much better than them in gubernatorial races and ballot propositions. With only one county in our dataset using mechanical lever machines and for only one election, we cannot draw any conclusions about the historical use of that technology in California.

We also conducted the first analysis of the effects of the rise of vote-by-mail in a residual vote context, and here we find trends that should cause election reformers pause. Regardless of the race, increasing the percentage of voters in a county using the mail to vote is robustly associated with a rise in the residual vote rate in that county. The effect is so strong that we estimate that the rise of voting by mail has mostly wiped out all the reductions in residual votes that were due to improved voting technologies since the early 1990s.

These findings have implications for policymaking in California, of course, but they also have implications for thinking about the most important issues in how elections are run throughout the United States. In particular, they are relevant to considering the trade-off between accuracy and convenience. Ever since election administration became more salient following the 2000 presidential election, the debate has often focused on accuracy and convenience.<sup>15</sup> Because it was a key feature of the Florida controversy in 2000, the issue of the accuracy of voting machines, broadly considered, has been well-studied and the subject of important state, local, and federal legislation since 2000. As reported here and elsewhere, the result has been to improve significantly the accuracy of the voting experience for average voters since 2000. Greater convenience in voting, such as making vote-by-mail easier, clearly benefits

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<sup>15</sup> Accuracy touches on issues like ballot design and other factors affecting the voting interface and the use of machines, rather than human beings, to count ballots. Convenience touches on issues like whether to have early voting, to use vote centers, and whether to make it easier to vote by mail.

existing voters if we measure the benefit in terms of time spent voting. And many studies have focused on the convenience of voting by mail. (See the summary of this literature in Alvarez, Levin and Sinclair 2011.) The findings in this paper suggest that this convenience comes at a cost, which is a significantly greater chance that the vote will not be counted once it is received at the county election office. Yet the costs of convenience have not been subjected to the same degree of skeptical, scientific scrutiny, and the results here suggest they should be. If we combine this with the significantly greater likelihood that mail ballots may not be received by the county election office in time to be counted in the first place (Stewart 2011b; Alvarez, Hall and Sinclair 2008), there are serious questions about whether the cost of convenience is good for the functioning of the electoral system.

This is not to say that the rise of the vote-by-mail system is unambiguously bad, just that its full array of costs and benefits have not been subjected to the necessary scrutiny. If nothing else, we hope that this paper will prompt further research into the matter.

While this paper extends previous analysis in new directions, it opens up new research that should be done to verify and hone its findings. In particular, the effect of the rise of vote-by-mail has been estimated here using an aggregate measure of how many voters in each county vote absentee in each election. A more accurate way of estimating this effect would be to study separately the residual vote rate in each county, separating ballots received by mail from ballots cast in person (either on election day or in early voting.) Unfortunately, few California counties currently report election returns this way, and we will be unable to make much more progress on this question until they do. In a related fashion, some studies (Kousser and Mullin 2007, Bergman and Yates 2009) attempt to take advantage of provisions in California law that *require* some voters in certain precincts to vote by mail in a quasi-random fashion to estimate the effect

of vote-by-mail on turnout, using a “natural experiment” design. It would be quite possible to extend these studies to have the residual vote rates of these ballots compared against a matched sample of precincts in which voters were not required to vote by mail.

Finally, the results of this paper have implications for the current question in the largest electoral jurisdiction in America, Los Angeles County, about the future of its election system. First, InkaVote has been a mixed blessing. It has reduced the number of lost votes in presidential elections, but considering the lopsided margins California has given Democratic presidential candidates over the past decade, this improvement has had little impact on the actual vote outcome. The statewide races tend to be closer and, of course, are *state* offices. Therefore, Los Angeles County voters have more at stake. For these statewide races, InkaVote ranges from being as good as conventional optical scanning systems to being no better than the discredited Votomatic punch cards.

Second, the results of this paper suggest that in order to fully assess the quality of a voting technology it is important to assess it at various levels of the ballot. What one finds at the very top will not necessarily be found at the bottom. This suggests that as Los Angeles County assesses the usability of a new system, officials should not simply stop at making sure the new system helps voters cast their intended vote in high-profile races.

Third, the results in this paper suggest that Los Angeles County, along with other counties, should hesitate before encouraging more residents to vote by mail. Admittedly, the results concerning voting by mail are preliminary and based on a blunt estimation technique, but the results are surprisingly clear nonetheless: more voting by mail is associated with more residual votes. If the goal is to ensure that every vote counts, measures that increase the

convenience of in-precinct voting would be much superior to those that encourage a new surge in mail-in balloting.

## References

- Alvarez, R. Michael, Thad E. Hall and Betsy Sinclair. 2008. Whose Absentee Votes are Returned and Counted: The Variety and Use of Absentee Ballots in California. *Electoral Studies* 27(4) 673-683.
- Alvarez, R. Michael, Stephen Ansolabehere and Charles Stewart III. 2005. Studying Elections: Data Quality and Pitfalls in Measuring of Effects of Voting Technologies. *Policy Studies Journal* 33(1): 15-24.
- Alvarez, R. Michael, Ines Levin and J. Andrew Sinclair. 2011. Making Voting Easier: Convenience Voting in the 2008 Presidential Election. *Political Research Quarterly*, forthcoming.
- Ansolabehere, Stephen. 2002. Voting Machines, Race, and Equal Protection. *Election Law Journal* 1(1): 61-70.
- Ansolabehere, Stephen and Charles Stewart III. 2005. Residual Votes Attributable to Technology." *Journal of Politics* 67(2): 365-389.
- Arnold, Ed. 1999. History of Voting Systems in California, edited by California Secretary of State. Sacramento.
- Asher, Herb, Russell Schussler, and Peg Rosenfield. 1982. The Effect of Voting Systems on Voter Participation. Paper presented at the annual meeting of the Midwest Political Science Association, Milwaukee, April 28-May 1.
- Bergman, Elizabeth and Philip Yates 2009. How Does Vote by Mail Affect Voters? A Natural Experiment Examining Individual-Level Turnout. Paper presented at the annual meeting of the Midwest Political Science Association, Chicago, April 3, 2009.
- Boehmke, Frederick J. 2005. *The Indirect Effect of Direct Legislation: How Institutions Shape Interest Group Systems*. Columbus: The Ohio State University Press.
- Bowler, Shaun, Todd Donovan, and Trudi Happ. 1992. Ballot Propositions and Information Costs: Direct Democracy and the Fatigued Voter. *Western Political Quarterly* 45(2): 559-68.
- Cain, Bruce E. and Noll, Roger. 2010. Institutional Causes of California's Budget Problem. *California Journal of Politics and Policy* 2(3), Article 1.
- Caltech/MIT Voting Technology Project. 2001. *Voting: What Is/What Could Be*. Pasadena and Cambridge.
- Darcy, R, and Anne Schneider. 1989. Confusing Ballots, Roll-Off, and the Black Vote. *Western Political Quarterly* 42(3): 347-64.

- Fraser, Jeannette Lynn. 1985. The Effects of Voting Systems on Voter Participation: Punch Card Voting Systems in Ohio. Ph.D. thesis. The Ohio State University.
- Gerber, Elisabeth R. 1999. *The Populist Paradox: Interest Group Influence and the Promise of Direct Legislation*. Princeton: Princeton University Press.
- Gerber, Elisabeth R., Mathew D. McCubbins, and D. Roderick Kiewiet. 2001. *Stealing the Initiative: How State Government Responds to Direct Democracy*. Upper Saddle, NJ: Prentice Hall.
- Gronke, Paul, Eva Galanes-Rosenbaum, Peter A. Miller and Daniel Toffey. 2008. Convenience Voting. *Annual Review of Political Science* 11:437-55.
- Gronke, Paul, Charles Stewart III, and James Hicks. 2010. Residual Voting in Florida. Washington: Pew Center on the States.
- Hajna, Zoltan L., Elisabeth R. Gerber, and Hugh Louch. 2002. Minorities and Direct Legislation: Evidence from California Ballot Proposition Elections. *Journal of Politics* 64(1): 154–77.
- Kahn, Matthew E. and John G. Matsusaka. 1997. Demand for Environmental Goods: Evidence from Voting Patterns on California Initiatives. *Journal of Law and Economics* 40(1): 137–73.
- Kimball, David C. and Martha Kropf. 2008. Voting Technology, Ballot Measures, and Residual Votes. *American Politics Research* 36(4): 479–509.
- Kousser, Thad and Megan Mullin. 2007. Does Voting by Mail Increase Participation? Using Matching to Analyze a Natural Experiment. *Political Analysis* 15(4), 428-445.
- Los Angeles Registrar-Recorder/County Clerk (LACRR). 2010. Voting Systems Assessment Project Report.  
[http://www.lavote.net/Voter/VSAP/PDFS/VSAP\\_Project\\_Report\\_070910\\_FINAL.pdf](http://www.lavote.net/Voter/VSAP/PDFS/VSAP_Project_Report_070910_FINAL.pdf).
- Lott, John R. 2009. Non-Voted Ballots, the Cost of Voting, and Race. *Public Choice* 138(1): 171–97.
- Lupia, Arthur. 1994. Shortcuts *versus* Encyclopedias: Information and Voting Behavior in California Insurance Reform Elections. *American Political Science Review* 88(1): 63–76.
- Magleby, David B. 1984. *Direct Legislation: Voting on Ballot Propositions in the United States*. Baltimore: The Johns Hopkins University Press.
- Mather, George B. 1964. *Effects of the Use of Voting Machines on Total Votes Cast, Iowa—1920–1960*. Iowa City: Institute of Public Affairs, University of Iowa.
- \_\_\_\_\_. 1986. *Lost Votes: Effects of Methods of Voting on Voter Participation, Iowa 1920-1984*. Iowa City: Institute of Public Affairs, University of Iowa.

Matsusaka, John G. 2004. *For the Many or the Few: The Initiative Process, Public Policy, and American Democracy*. Chicago: University of Chicago Press.

Montgomery, Michael J. 1982. New Voting Technology: Some Potential Sources of Disenfranchisement. Paper presented at the annual meeting of the Humanities and Technology Association, Marietta, Georgia. Cited in Shocket, Heighberger, and Brown (1992).

Mueller, John E. 1969. Voting on the Propositions: Ballot Patterns and Historical Trends in California. *American Political Science Review* 63(4):1197-1212.

Nichols, Stephen M. 1998. State Referendum Voting, Ballot Roll-Off, and the Effect of New Electoral Technology. *State and Local Government Review* 30(2): 106–17.

Nichols, Stephen M and Gregory A Strizek. 1996. Electronic Voting Machines and Ballot Roll-Off. *American Politics Research* 23(3): 300-18.

Sinclair, Robert C., Melvin M. Mark, Sean E. Moore, Carrie A. Lavis, and Alexander S. Soldat. 2000. Psychology: An Electoral Butterfly Effect.” *Nature* 408: 665–66.

Sinclair, D. E. “Betsy” and R. Michael Alvarez. 2004. Who Overvotes, Who Undervotes, Using Punchcards? Evidence from Los Angeles County. *Political Research Quarterly* 57(1): 15–25.

Smith, Richard L. 2002. A Statistical Assessment of Buchanan’s Vote in Palm Beach County. *Statistical Science* 17(4): 441–57.

Stewart, Charles, III. 2006. Residual Vote in the 2004 Election. *Election Law Journal* 5(2), 158–69.

\_\_\_\_\_. 2011a. Losing Votes by Mail. *NYU Journal of Legislation and Public Policy*. Forthcoming.

\_\_\_\_\_. 2011b. Voting Technology. *Annual Review of Political Science* 14 14:355–80.

Thomas, Norman C. 1968. Voting Machines and Voter Participation in Four Michigan Constitutional Revision Referenda.” *Western Political Quarterly* 21(3):409–19.

Tomz, Michael and R. Van Houweling, 2003. How Does Voting Equipment Affect the Racial Gap in Voided Ballots? *American Journal of Political Science* 47(1): 46–60.

Walker, Jack L. 1966. Ballot Forms and Voter Fatigue: An Analysis of the Office Block and Party Column Ballots. *Midwest Journal of Political Science* 10(4): 448–63.

Wand, Jonathan N., Kenneth W. Shotts, Jasjeet S. Sekhon, Walter R. Mebane, Michael C. Herron, and Henry E. Brady. 2001. The Butterfly Did It: The Aberrant Vote for Buchanan in Palm Beach County, Florida. *American Political Science Review* 95(4): 793-810.

White, John P. 1960. *Voting Machines and the 1958 Defeat of Constitutional Revision in Michigan*. Ann Arbor: University of Michigan.



Table 1. Pre-2000 studies on ballot roll-off

Citation	Geographic coverage	Offices studied	Year(s)	Baseline for turnout	Finding
White (1960)	Michigan	Referendum	1958	Vote for governor	Lever machines had higher roll-off
Mather (1964)	Iowa	Top vote-getter; Referenda	1920-1960	Eligible electorate; votes cast for race with most total votes	Paper-ballot counties had higher turnout; Lever machines had higher roll-off
Thomas (1968)	Michigan	Referenda	1958-1963	Total votes for partisan office receiving the most total votes on ballot	Lever machines had higher roll-off
Asher, Schussler, and Rosenfield (1982)	Ohio	Governor (primarily) and other down-ballot state races	1974–1980	Turnout	Punch cards cause more lost votes at top of ballot, but many fewer down-ballot
Montgomery (1982)*	Michigan	Special elections	Unknown	Unknown	Punch cards experience more “vote loss”
Fraser (1985)	Ohio	All statewide contests	1974-1982	Turnout	Punch card have higher roll-off for governor; machines have higher roll-off down-ballot, including referenda
Mather (1986)	Iowa	Top vote-getter; Referenda	1920–1984	Eligible electorate; votes cast for race with most total votes	Paper-ballot counties had higher turnout; Lever machines had higher roll-off
Darcy and Schneider (1989)	Oklahoma	All statewide contests	1986	Presumably turnout	Opscan ballots with “confusing” layouts experience more roll-off; otherwise, opscan ballots have less roll-off
Nichols and Strikek (1995)	Columbus, Ohio	Federal, state, & county offices	1992	Votes cast for president	Electronic voting machines produce less roll-off, except for U.S. Senate
Nichols (1998)	Kentucky	Constitutional referenda	1992, 1996	Votes cast in “major partisan office”	Electronic voting machines produce less roll-off in referenda

\*Cited in Shocket, Heighberger, and Brown (1992).

Table 2. Residual vote rates for president, U.S. Senate, and ballot measures, 1992 – 2008, and governor, 1990–2010.

Election year	Candidates			Ballot measures							
	Pres.	Gov.	Sen.	All		Measure with lowest resid. vote rate			Measure with highest resid. vote rate		
	Resid. Vote Rate	Resid. Vote Rate	Resid. Vote Rate	Number of measures	Avg. Resid. Vote Rate	No.	Official title	Resid. Vote Rate	No.	Official title	Resid. Vote Rate
1990	---	2.5%	---	28	9.8%	128	Environment. Public Health. Bonds. Initiative Statute	6.4%	141	Toxic Chemical Discharge. Public Agencies. Legislative Statute (Senate Bill 65, Statutes of 1990, Chapter 407)	13.0%
1992	2.1%	---	5.1%	13	9.8%	161	Physician-Assisted Death. Terminal Condition.	6.8%	159	Office of the Auditor General.	14.9%
1994	---	2.6%	4.3%	10	9.7%	187	Illegal Aliens. Ineligibility for Public Services. Verification and Reporting.	3.5%	191	Abolish Justice Courts	18.8%
1996	2.4%	---	---	15	8.4%	215	Medical Use of Marijuana.	5.6%	216	Health Care. Consumer Protection. Taxes on Corporate Restructuring.	11.0%
1998	---	2.7%	3.5%	12	10.5%	5	Tribal-State Gaming Compacts. Tribal Casinos.	5.3%	11	Local Sales and Use Taxes--Revenue Sharing	15.2%
2000	1.6%	---	4.7%	8	10.1%	38	School Vouchers. State-Funded Private and Religious Education. Public Funding.	5.8%	37	Fees. Vote Requirements. Taxes.	13.6%
2002	---	3.4%	---	7	9.8%	47	Kindergarten-University Public Education Facilities Bond Act of 2002.	7.6%	48	Court Consolidation	14.0%
2004	1.3%	---	4.3%	16	10.2%	71	Stem Cell Research. Funding. Bonds. Initiative Constitutional Amendment and Statute	5.6%	65	Local Government Funds, Revenues. State Mandates.	17.6%
2006	---	2.5%	4.0%	13	6.1%	86	Tax on Cigarettes. Initiative Constitutional Amendment and Statute.	3.8%	84	Water Quality, Safety and Supply. Flood Control. Natural Resource Protection. Park Improvements. Bonds. Initiative	7.4%
2008	1.3%	---	---	12	8.1%	8	Eliminates Right of Same-Sex Couples to Marry. Initiative Constitutional Amendment.	2.5%	11	Redistricting. Initiative Constitutional Amendment and Statute.	12.7%
2010	---	2.0%	2.9%	9	7.4%	19	Legalizes Marijuana under California but not Federal Law.	3.2%	27	Eliminates State Commission on Redistricting.	10.6%

Figure 1. Graph of values from Table 1.

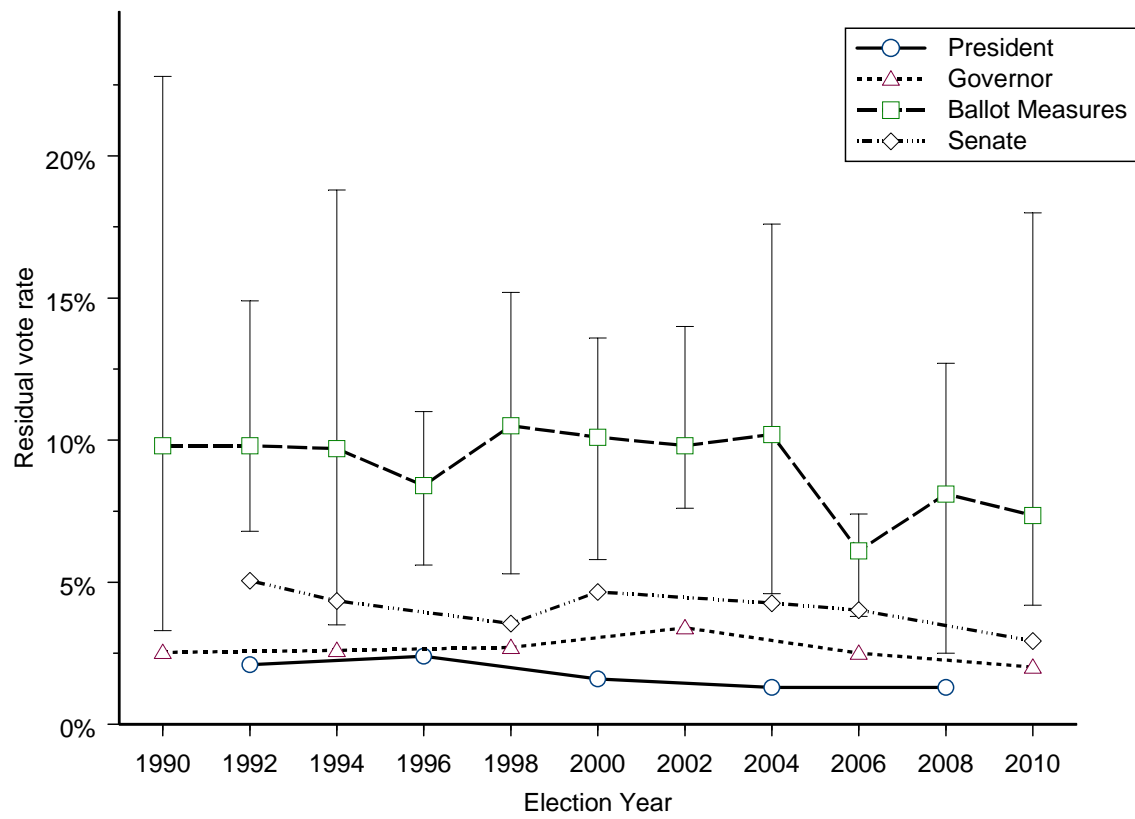


Table 3. Use of voting technologies in California, by number of voters and number of counties, 1992–2010

	Mechanical lever		Punch, Votomatic		Punch, Datavote		Optical scan, central count		Optical scan, precinct count		DRE		InkaVote	
Year	Voters	Cnty	Voters	Cnty	Voters	Cnty	Voters	Cnty	Voters	Cnty	Voters	Cnty	Voters	Cnty
1990	34,669	1	4,891,264	17	1,963,447	31	1,009,751	9	0	0	0	0	0	0
1992	49,958	1	6,951,797	15	2,492,252	29	1,583,075	11	297,483	2	0	0	0	0
1994	0	0	5,313,966	13	1,941,102	28	1,411,849	15	233,715	2	0	0	0	0
1996	0	0	6,112,148	12	2,117,080	28	1,708,631	15	325,653	3	0	0	0	0
1998	0	0	5,092,521	12	1,786,994	28	1,466,862	15	271,272	3	0	0	0	0
2000	0	0	5,947,871	9	2,033,175	21	1,150,538	11	1,556,182	16	455,077	1	0	0
2002	0	0	3,636,190	8	1,441,440	20	858,540	11	1,138,167	16	664,484	3	0	0
2004	0	0	0	0	601,657	12	2,547,851	11	2,763,319	24	3,592,454	10	3,085,582	1
2006	0	0	0	0	0	0	387,481	8	2,893,092	27	3,585,367	22	2,033,119	1
2008	0	0	0	0	0	0	6,131,091	29	4,244,029	28	1,475,007	2	3,368,057	1
2010	0	0	0	0	0	0	3,645,053	28	3,155,702	27	1,124,464	2	2,377,105	1

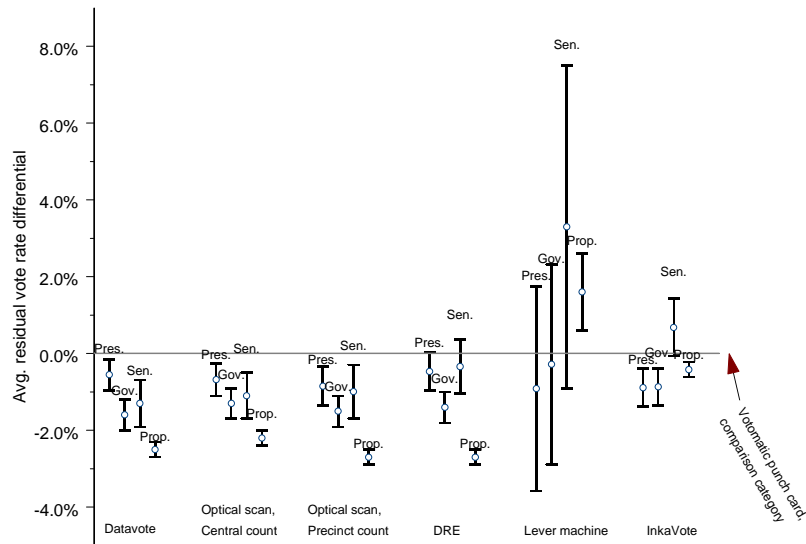
Table 4. Fixed effects regressions. (Standard errors in parentheses)

	President	Governor	Senator	Propositions
Voting machine				
Votomatic punch card	Omitted category	Omitted category	Omitted category	Omitted category
Datavote punch card	-0.0055 (0.0020)	-0.016 (0.002)	-0.013 (0.003)	-0.025 (0.001)
Optical scan, central count	-0.0068 (0.0021)	-0.013 (0.002)	-0.011 (0.003)	-0.022 (0.001)
Optical scan, precinct count	-0.0085 (0.0022)	-0.015 (0.002)	-0.0099 (0.0033)	-0.027 (0.001)
DRE	-0.0047 (0.0025)	-0.014 (0.002)	-0.0034 (0.0035)	-0.027 (0.001)
Lever machine	-0.0091 (0.0133)	-0.0028 (0.0130)	0.033 (0.021)	0.016 (0.005)
Inkavote	-0.0089 (0.0025)	-0.0087 (0.0024)	0.0068 (0.0037)	-0.0042 (0.0010)
County adopted new technology	0.0014 (0.0012)	-0.0032 (0.0014)	-0.0011 (0.0017)	-0.00072 (0.00049)
Vote-by-mail pct.	0.022 (0.010)	0.033 (0.008)	0.049 (0.014)	0.030 (0.004)
log(turnout)	-0.0057 (0.0107)	0.0016 (0.0075)	0.0091 (0.0138)	-0.0020 (0.0033)
Year dummies	Yes	Yes	Yes	No
County dummies	Yes	Yes	Yes	Yes
Proposition dummies	n/a	n/a	n/a	Yes
N	290	348	406	8,294
R <sup>2</sup>	.66	.73	.63	.88
Adj. R <sup>2</sup>	.55	.67	.56	.88
Root M.S.E.	0.0060	0.0058	0.010	0.013

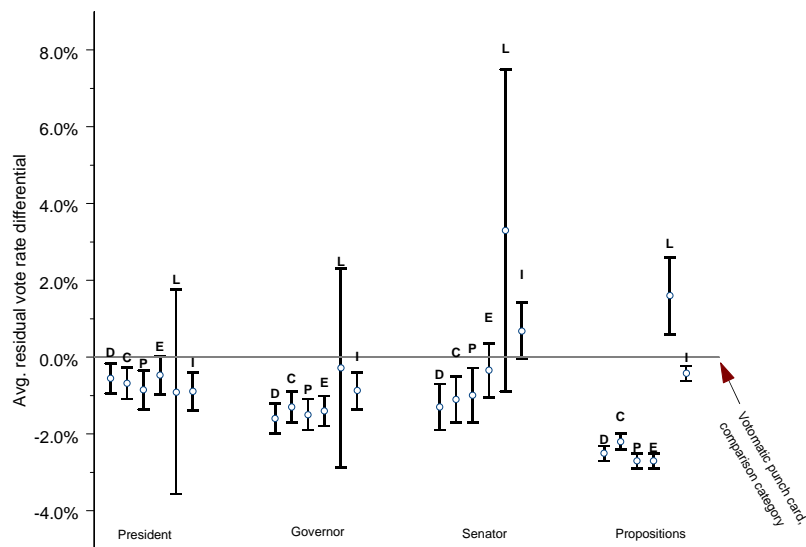
Coefficients not reported: Intercept, year dummies, county dummies, and proposition dummies.

Figure 2. Comparison of voting-technology-related coefficients from Table 4.

a. By method



b. By office



D = Datavote, C = Central-count optical scan, P = Precinct-count optical scan, E = DRE, L = Mechanical lever machine, I = InkaVote

Table 5. Calculation of net change in residual vote rate from 1992 to 2010, combining effects of voting technology and vote-by-mail.

County	Turnout		Vote-by-Mail Pct.			Voting equipment type		Voting technology effect		Vote-by-Mail Effect	Combined effect
	1992	2008	1992	2008	Change	1992	2008	Net rv change pct	Net votes	Net votes	Net votes
Alameda	541,928	628,545	12.7%	48.3%	35.6%	Punch	Opscan-P	-0.85%	-5,343	4,925	-418
Alpine	638	697	22.1%	100.0%	77.9%	Punch	Opscan-C	-0.68%	-5	12	7
Amador	15,692	19,006	16.5%	51.8%	35.4%	Opscan-C	Opscan-P	-0.17%	-32	148	116
Butte	88,446	99,392	18.0%	49.4%	31.5%	Punch	Opscan-C	-0.68%	-676	688	12
Calaveras	17,516	23,588	24.7%	58.5%	33.8%	Punch	Opscan-P	-0.85%	-200	176	-25
Colusa	5,860	6,532	19.7%	49.3%	29.6%	Punch	Opscan-P	-0.85%	-56	43	-13
Contra Costa	389,391	456,876	19.7%	47.6%	27.9%	Opscan-C	Opscan-P	-0.17%	-777	2,805	2,028
Del Norte	9,687	9,684	27.5%	48.4%	20.9%	Punch	Opscan-C	-0.68%	-66	45	-21
El Dorado	66,949	93,890	19.8%	54.7%	34.9%	Punch	Opscan-P	-0.85%	-798	722	-76
Fresno	224,241	275,554	18.6%	45.3%	26.7%	Punch	Opscan-P	-0.85%	-2,342	1,618	-724
Glenn	9,143	10,053	14.5%	36.8%	22.2%	Punch	Opscan-C	-0.68%	-68	49	-19
Humboldt	61,030	64,358	17.2%	40.6%	23.5%	Punch	Opscan-P	-0.85%	-547	332	-215
Imperial	27,597	39,823	12.0%	32.3%	20.2%	Punch	Opscan-C	-0.68%	-271	177	-94
Inyo	8,588	8,625	18.7%	43.2%	24.5%	Punch	Opscan-C	-0.68%	-59	47	-12
Kern	185,781	235,854	14.1%	41.2%	27.1%	Punch	Opscan-C	-0.68%	-1,604	1,405	-199
Kings	26,326	35,775	15.7%	64.2%	48.6%	Punch	Opscan-C	-0.68%	-243	382	139
Lake	24,035	25,863	20.5%	53.3%	32.8%	Opscan-C	Opscan-C	0.00%	0	186	186
Lassen	10,510	11,510	15.6%	44.2%	28.6%	Punch	Opscan-P	-0.85%	-98	72	-25
Los Angeles	2,831,077	3,368,057	13.7%	24.1%	10.3%	Punch	InkaVote	-0.89%	-29,976	7,652	-22,324
Madera	31,222	43,032	18.4%	54.0%	35.6%	Opscan-C	Opscan-C	0.00%	0	337	337
Marin	132,422	141,321	19.2%	58.7%	39.5%	Punch	Opscan-P	-0.85%	-1,201	1,228	27
Mariposa	8,469	9,756	24.8%	55.3%	30.4%	Opscan-C	Opscan-C	0.00%	0	65	65
Mendocino	37,658	40,580	15.2%	22.2%	7.0%	Punch	Opscan-C	-0.68%	-276	62	-213
Merced	49,958	64,688	16.0%	40.3%	24.3%	Mechanical	Opscan-P	0.06%	39	346	385
Modoc	4,702	4,505	18.2%	31.8%	13.6%	Punch	Opscan-P	-0.85%	-38	14	-25
Mono	4,499	5,621	17.7%	33.7%	16.0%	Punch	Opscan-P	-0.85%	-48	20	-28
Monterey	118,303	131,381	24.9%	58.8%	33.9%	Punch	Opscan-C	-0.68%	-893	980	86
Napa	55,090	60,366	17.2%	27.5%	10.3%	Punch	Opscan-C	-0.68%	-410	137	-273
Nevada	45,414	56,177	23.6%	69.5%	45.9%	Opscan-C	Opscan-P	-0.17%	-96	567	471
Orange	979,024	1,167,657	15.4%	46.5%	31.1%	Punch	DRE	-0.47%	-5,488	7,989	2,501
Placer	93,438	175,215	23.4%	55.6%	32.2%	Punch	Opscan-P	-0.85%	-1,489	1,239	-250
Plumas	10,521	11,169	23.0%	58.7%	35.8%	Punch	Opscan-P	-0.85%	-95	88	-7
Riverside	434,316	657,005	18.1%	41.5%	23.5%	Opscan-C	Opscan-C	0.00%	0	3,392	3,392
Sacramento	461,887	546,660	14.6%	44.2%	29.6%	Punch	Opscan-P	-0.85%	-4,647	3,560	-1,087
San Benito	13,207	19,982	19.1%	43.3%	24.2%	Punch	Opscan-C	-0.68%	-136	106	-29
San Bernardino	482,162	616,320	14.8%	37.2%	22.4%	Punch	Opscan-C	-0.68%	-4,191	3,042	-1,149

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	1992	2008	1992	2008	Change	1992	2008	Net rv change pct	Net votes	Net votes	Net votes
San Diego	1,002,914	1,245,947	24.4%	46.0%	21.6%	Punch	Opscan-C	-0.68%	-8,472	5,926	-2,546
San Francisco	329,695	388,112	22.6%	46.0%	23.4%	Punch	Opscan-P	-0.85%	-3,299	1,996	-1,303
San Joaquin	165,909	212,214	18.4%	48.0%	29.6%	Opscan-C	Opscan-C	0.00%	0	1,381	1,381
San Luis Obispo	107,144	134,061	23.9%	51.0%	27.1%	Punch	Opscan-P	-0.85%	-1,140	800	-339
San Mateo	281,791	307,350	20.2%	48.1%	27.8%	Opscan-C	DRE	0.21%	645	1,883	2,529
Santa Barbara	164,705	176,562	22.2%	52.2%	30.0%	Opscan-C	Opscan-P	-0.17%	-300	1,164	864
Santa Clara	610,002	678,033	13.5%	57.3%	43.8%	Punch	Opscan-C	-0.68%	-4,611	6,534	1,923
Santa Cruz	116,527	128,555	20.3%	47.1%	26.8%	Punch	Opscan-P	-0.85%	-1,093	757	-336
Shasta	69,223	81,378	15.0%	51.8%	36.8%	Punch	Opscan-C	-0.68%	-553	659	106
Sierra	1,918	2,012	21.3%	100.0%	78.7%	Punch	Opscan-C	-0.68%	-14	35	21
Siskiyou	21,428	21,723	18.1%	61.3%	43.2%	Punch	Opscan-P	-0.85%	-185	206	22
Solano	134,444	162,638	16.1%	51.1%	35.0%	Punch	Opscan-P	-0.85%	-1,382	1,253	-130
Sonoma	201,499	231,817	20.1%	59.4%	39.3%	Opscan-C	Opscan-C	0.00%	0	2,005	2,005
Stanislaus	131,398	162,941	31.1%	52.9%	21.8%	Punch	Opscan-P	-0.85%	-1,385	782	-603
Sutter	26,456	33,337	23.9%	68.3%	44.4%	Opscan-C	Opscan-C	0.00%	0	326	326
Tehama	22,071	24,803	14.7%	54.8%	40.2%	Punch	Opscan-C	-0.68%	-169	219	50
Trinity	6,806	6,482	30.6%	36.6%	6.0%	Punch	Opscan-P	-0.85%	-55	9	-47
Tulare	91,659	106,551	13.0%	36.8%	23.8%	Opscan-C	Opscan-P	-0.17%	-181	558	377
Tuolumne	24,526	27,499	22.6%	51.6%	29.0%	Punch	Opscan-P	-0.85%	-234	175	-59
Ventura	276,404	343,690	19.1%	43.5%	24.4%	Punch	Opscan-P	-0.85%	-2,921	1,846	-1,075
Yolo	63,394	80,674	15.0%	47.1%	32.1%	Punch	Opscan-C	-0.68%	-549	570	21
Yuba	17,925	21,681	21.0%	48.0%	27.0%	Punch	Opscan-C	-0.68%	-147	129	-19

Note: Some sums do not add up due to rounding error.